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SYSTEMATIC REVIEW

EFFECTIVENESS OF ULTRASONOGRAPHY IN DIAGNOSING CHRONIC LATERAL ANKLE INSTABILITY:A SYSTEMATIC REVIEW

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ABSTRACT

Background: Chronic ankle instability (CAI) is a condition that often develops after repeated ankle sprains, increasing the suceptability of the ankle to move into excessive inversion when walking on unstable surfaces. Treatment for CAI costs approximately three billion health care dollars annually. Currently, common diagnostic tools used to identify ankle instability are arthroscopy, imaging, manual laxity testing, and self-reported questionnaires.

Purpose: The purpose of this systematic review was to investigate the effectiveness of ultrasonography in diagnosing CAI, in comparison with other diagnostic tools.

Methods: Search limits: articles published between the years 2000-2015, and articles that were peer reviewed and published in the English language. Databases searched: CINAHL, PubMed, Medline, Medline Plus, Science Direct, OVID, Cochrane, and EBSCO. Titles and abstracts of the 1,420 articles were screened for the inclusion criteria by two independent raters, with discrepancies solved by a third rater. The modified 14-point Quality Assessment of Diagnostic Accuracy Studies (QUADAS) scale was used to assess methodological quality of included articles.

Results: Six high quality articles were included in this systematic review, as indicated by high scores on the QUADAS scale, ranging from 10 to 13. Sensitivity of US ranged from: 84.6 % -100%, specificity of US ranged from: 90.9% - 100% and accuracy ranged from: 87% - 90.9%.

Discussion: The results of the included studies suggest that US is able to accurately differentiate between the grades of ankle sprains and between a lax ligament, torn ligament, thick ligament, absorbed ligament and a non-union avulsion fracture. These findings indicate that US is a reliable method for diagnosing CAI, and that US is able to classify the degree of instability.

Conclusion: Researchers found that US is effective, reliable, and accurate in the diagnosis of CAI.

Clinical Implications: US would allow for earlier diagnosis, which could increase the quality of care as well as decrease the number of outpatient visits. This could lead to improvement in treatment plans, goals and rehabilitation outcomes.

level of Evidence: 1a

Keywords: chronic ankle instability, ultrasonography, magnetic resonance imaging

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INTRODUCTION

Chronic ankle instability (CAI) is a condition that often develops after repeated ankle sprains, increasing the suceptability of the ankle to move into excessive inversion when walking on unsteady surfaces. Approximately 74% of acute ankle sprains result in persistent symptoms (Houston et al., 2014), 30% of which progress to chronic ankle instability.[1] CAI is diagnosed in individuals who report pain and tenderness on the lateral aspect of the ankle, or persistent swelling and discomfort for greater than six months with a history of reinjury or clinical instability of the ankle joint.[2,3] In the long-term, CAI can have negative implications on an individual's participation in recreational activities, as well as occupational duties.[2]

The primary cause of damage to the structural stability of the ankle joint is trauma by forced inversion and plantarflexion.[4] The lateral collateral ligaments, which are more commonly affected by acute sprains, include the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL), and the posterior talofibular ligament (PTFL). The ATFL is primarily responsible for preventing excessive supination and anterior translation, while also restricting plantar flexion and internal rotation.[5]

Inversion ankle sprains, affecting the lateral ligaments of the ankle, comprise 85% of all ankle injuries.[6] Lateral ankle sprains are the most common injury occurring in both high school and collegiate athletics, but also affect approximately eight percet of the general population.[7,8,9]

DIAGNOSIS OF CAI

Common diagnostic tools used to identify ankle instability include arthroscopy, imaging, manual testing (like Anterior Drawer Test), and self-reported questionnaires. Arthroscopic examination and magnetic resonance imaging (MRI) are considered the two most accurate methods of diagnosing injuries to lateral collateral ligaments.[10] While arthroscopy allows direct visual access to the intra-articular structures, it is an invasive surgical procedure that could result in serious consequences such as infection or damage to neurologic, vascular, cartilage or ligamentous structures.[11] Imaging techniques, which are less invasive than arthroscopy, include MRI, computed tomography (CT) scan, and radiographs. Radiologists use MRI to diagnose CAI due to its ability to visualize damage to the ligaments, as well as surrounding soft tissue structures.[12] The ATFL is best visualized on MRI in an axial view through the level of the malleolar fossa; it will be seen just below the tibiotalar joint. CAI is indicated by a disruption in or thickening of the ligament.[13] In a retrospective study conducted by Joshy et al., in which 24 patients underwent arthroscopy and MRI of the ankle, MRI was found to have both high specificity (100%) and high sensitivity (100%) for ATFL disruption.[14]

The other imaging techniques that are used include raditographs and CT scan. These are the primary imaging techniques used to visualize bony structures and abnormalities. They can also be used to estimate the degree of ankle instability.[15] A radiograph may include an image taken with the ankle placed on stress in order to enhance its ability to detect soft tissue changes.[14]

Diagnostic ultrasound works by transmitting sound waves into the tissues through a transducer, which then reflect back to display an image of the tissues. Once an image is produced, a digital caliper is used to measure the length of the ligaments. When imaging the ankle, ultrasound is able to detect synovial lesions, ligamentous injury, and distinguish soft tissue from osseous impingement.[14] Dynamic ultrasound can also be used to discover dislocation of the peroneal tendons, or intrasheath dislocation, which is indicated by an intact retinaculum with subluxation of the peroneal tendons within the groove.[16]

Ultrasound has been proven able to detect soft tissue injuries, and has even become the gold standard for the detection of injuries to the patellar and Achilles tendons.[16] Ultrasound is currently being used for diagnosing ligamentous and muscular sports injuries; however, the use of ultrasound and its' ability to accurately diagnose CAI is still under debate. The purpose of this systematic review is to investigate the effectiveness of ultrasound in diagnosing CAI, in comparison with other diagnostic tools (arthroscopy, imaging, and clinical testing) . This will assist rehabilitation professionals to better diagnose and manage cases of CAI.

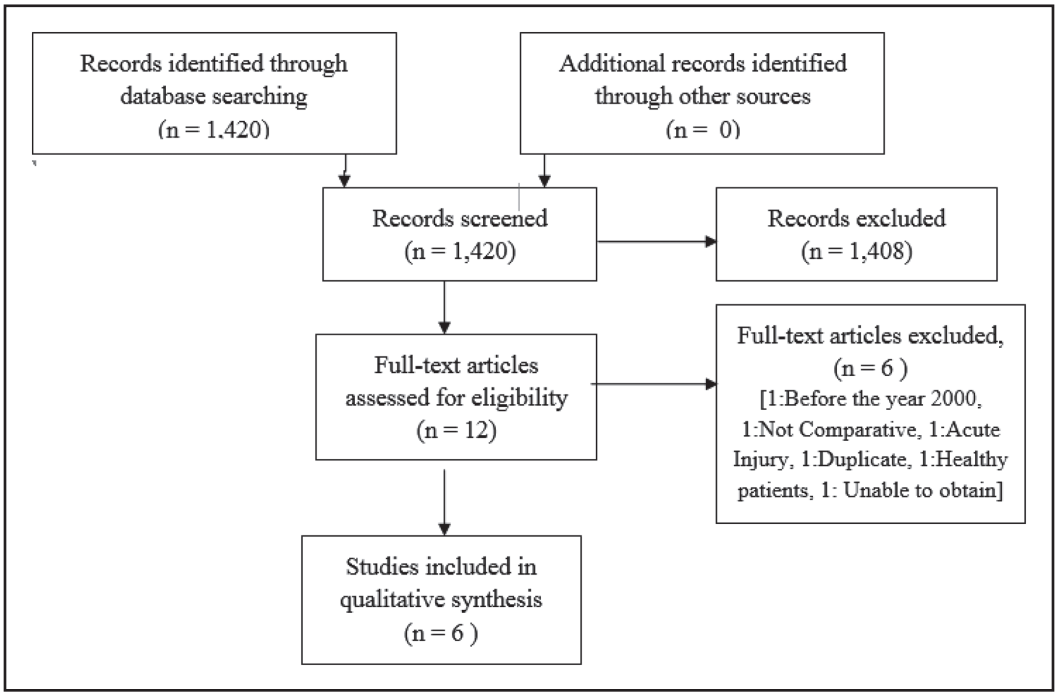

Figure 1. *Flow diagram of the steps of article search, screening, and final review process*

METHODS

Researchers independentely searched English language articles published between the years 2000-2015. Databases searched included CINAHL, PubMed, Medline, Medline Plus, Science Direct, OVID, Cochrane, and EBSCO. Keywords utilized in the search process included 'chronic ankle instability, ultrasonography, ankle instability, diagnostic imaging, ankle lateral collateral ligament, talofibular ligament and MRI'.

Two independent raters searched each key word set; this initial search resulted in 1,420 articles. The titles and abstracts of the 1,420 articles were screened for the inclusion criteria by two independent raters. In order to be included in the review, the article had to be a diagnostic trial that included comparison between ultrasound and another reference measure (gold standard), to assess chronic lateral ankle instability. When discrepancies occurred between the two independent raters on which articles to include, a third rater made the final decision. Following the screening process, only six articles met inclusion criteria. Figure 1 represents the steps of initially screening titles and abstracts as well as full article review. The quality of each article was assessed by two independent raters using the modified 14-point QUADAS scale. Discrepancies in the raters' findings were resolved by a third rater or by consensus between the two initial raters. The search results are summarized in Table 1 and the methodological quality of included articles is summarized in the following color coded QUADS table (Table 2)

RESULTS

Summary of Included Articles

Lee et al sought to evaluate the effectiveness of stress ultrasonography (US) in comparison with stress radiography and an anterior drawer stress test.[17] Patients with chronic ankle pain or laxity, lasting for at least three months, were included in this study; patients with generalized laxity and acute sprains were excluded from the study. Two foot and ankle surgeons evaluated seventy-three patients. They performed a standardized physical examination including the three tests listed above to assess the integrity of the anterior talofibular ligament (ATFL). A second rater who had no knowledge of the clinical history or the results of the physical examination also evaluated the images. The correlation coefficient between the length of the ATFL on US and

Table 1. *Summary table of search results*

Authors	Modified 14 point QUADAS score	Study Design	Sample Size	Study Purpose	Diagnostic Procedure	Outcome Measure	Conclusion
Yi Cheng, Yehua Cai, Yi Wang 2013	13/14	Prospective comparative study	Total: 120 Men: 85 Women: 35 Mean age: 32 years Range: 15-70	-Study the effectiveness of ultrasound (US) for diagnosing lateral ankle ligament injuries as compared to arthroscopy.	US: Supine, maximally inverted and plantar flexed. Axial and transverse images were used bilaterally.	The contour and integrity of the ligaments were classified as: grade 0, no injury, grade 1, stretched or swollen ligament without tear, grade 2, partial tear, or grade 3, complete tear of the ligament.	Ultrasonography accurately identified the grade of injury with a sensitivity of 98.9%, 93.8% and specificity of 96.2%, 90.9% for detecting ATFL and CFL injury respectively.
Hua, Yang, Chen, Cai 2012	12/14	Prospective comparative study	Total: 83 Men: 51 Women: 32 Mean age: 32.2 years Range: 17-57	Determine the value of ultrasound examination of chronic ATFL injuries as compared to arthroscopic findings	US: Supine, maximum plantar flexion and inversion. Transducer placed along the long axis and then rotated 90 deg.	Ligament tear, Ligament laxity, Thick ligament, Ligament absorbed, Non-union of avulsion fracture of lateral malleolus	Ultrasound examination is reliable and accurate in diagnosing the grade of ATFL injury, indicated by high sensitivity (97.7%) and specificity (92.3%) as compared to arthroscopy
Gün C, Unlüer EE, Vandenberk N, Karagöz A, Sentürk GO, Oyar O 2013	11/14	Prospective Comparative Study	Total: 65 Men: 63% Women: 37% Mean age: 34.03± 12.85 years.	Accuracy of Bedside Ultrasonography in the diagnosing patients with an ATFL injury compared to MRI.	Bedside Ultrasonography Positioning: moderate inversion and plantar flexion of the ATFL	The integrity of the ATFL determined by a torn or abnormal hypoechoic lesion which was confirmed by MRI.	The diagnostic accuracy of BUS and MRI were not significantly different from each other based on findings of 93.8% sensitivity 100% specificity.
KT. Lee, YU. Park, H Jegal, JW. Park, JP Choi, JS. Kim 2013	11/14	Prospective comparative study	Total: 73 Men: 41 Women: 32 Mean age: 29 years old	Evaluate the diagnostic value of stress ultrasonography (US) compared to stress radiography in diagnosing patients with chronic ankle instability.	US: Sitting, transducer placed over ATFL and parallel to the sole of foot. Images taken in resting position and maximal stressed position.	US measured the ATFL length at rest and in the maximally stressed position. Anterior displacement of the talus was measured manually by anterior drawer test and mechanically while undergoing Stress radiography.	Stress ultrasound successfully identified the grades of ligamentous injury of the ATFL with a statistical significance of $p < 0.001$. The results were significantly correlated with the data obtained from ADT and were superior to those of stress radiograph.

Table 1. *Summary table of search results (continued)*

Guilodo,Y., Varache,S., A.Saraux 2010	10/14	Prospective Comparative Study	Total: 56 Men: 46 Women: 10 Mean age: 30.1±10.6 years.	A comparative study of US to Anterior Drawer Test and Computed Arthrotomography (CTA) in the diagnosis of ATFL injury.	This article did not provide information about the diagnostic procedures used.	ATFL damage was determined by US, anterior drawer test and CTA. Other details on outcome measures were deficient.	US is an effective and reliable tool in the diagnosis of chronic ankle instability compared to CTA as demonstrated by a sensitivity of 84.6%, specificity of 100% results were highly correlated with CTA findings (k=0.76).
Oae K, Takao M, Uchio Y, Ochi M. 2010	10/14	Prospective Comparative Study	Total: 34 Men: 19 Women: 15 Mean age: 29 years. Range:13-55. (19 acute and 15 chronic)	Evaluate the effectiveness of US, stress radiography (X-ray) ,MRI, and arthroscopy in the diagnosis of ATFL injury	US: The ankle was placed in moderate inversion and plantar flexion.	US diagnostic criteria: a discontinuation or a hypoechoic lesion that is seen within 5mm from the attachment site. MRI: A discontinuation, a wave or curved contour, and increased signal intensity within the ligament. Arthroscopy: An abnormal course of the ligament with a decrease in the tautness of the ligament or an avulsion at the attachment of the fibula or talus.	Ultrasonography and MRI are effective in the diagnosis of ATFL injuries compared to Arthroscopy with an 87% and 93% accuracy, respectively.

the grade of the anterior drawer stress test was 0.58. Results indicated that the stress US was able to differentiate between the three grades of the anterior drawer stress test findings. Researchers concluded that stress US is comparable to other conventional methods for diagnosing ligament laxity.[17]

Hua et al compared ultrasound with arthroscopy, the gold standard for diagnosing chronic ATFL injury.[15] Their sample consisted of 83 consecutive patients between the ages of 17 and 57 years. The patients had all had a preoperative diagnosis of an ankle injury and were examined using diagnostic ultrasound by a senior radiologist with 15 years of experience to determine ligament laxity, ligament tear, ligament width, ligament absorption and/or non-union of avulsion fracture[15]. The patient was positioned in supine with their ankle in passive maximal inversion and plantar flexion during the ultrasound procedure. All participants then underwent an arthroscopic procedure performed by a sports medicine surgeon who was blind to the ultrasound results.[15] Forty-four of the patients were diagnosed with an ATFL injury; US was 95.2% accurate in detecting ATFL injury. Hua et al found US to have a sensitivity of 97.7%, specificity of 92.3%, positive predictive value of 93.5%, negative predictive value of 97.3%, positive likelihood ratio (+LR) of 12.7 and negative likelihood ratio (-LR) of 0.025. These results indicate that US findings are likely to assist in diagnosing a patient with ATFL injury.[15]

Table 2. *Color Coded Modified 14 Point QUADAS*

Modified 14 Point QUADAS Items	Yi Cheng et al. 2013	Hua et al. 2012	Gün C et al. 2013	KT. Lee et al. 2013	Guilodo,Y. et al. 2010	Oae K. et al. 2010
1. Was the spectrum of patients representative of the patients who will receive the test in practice?						
2. Is the reference standard likely to classify the target condition correctly?						
3. Is the time period between reference standard and index test short enough to be reasonably sure that the target condition did not change between the two tests?						
4. Did the whole sample or a random selection of the sample, receive verification using the intended reference standard?						
5. Did patients receive the same reference standard irrespective of the index test result?						
6. Was the reference standard independent of the index test (i.e. the index test did not form part of the reference standard)?						
7. Were the reference standard results interpreted without knowledge of the results of the index test?						
8. Were the index test results interpreted without knowledge of the results of the reference standard?						
9. Were the same clinical data available when test results were interpreted as would be available when the test is used in practice?						
10. Were uninterpretable/intermediate test results reported?						
11. Were withdrawals from the study explained?						
12. Did the study provide a clear definition of what was considered to be a 'positive' result?						
13. Had test operators had appropriate training?						
14. Was treatment withheld until both the index test and reference standard were performed?						

Table Color Key:

YES: NO: NOT CLEAR

Cheng et al investigated the effectiveness of ultrasonography (US) in diagnosing lateral ligament injury in comparison with arthroscopy.[18] A sample of 485 patients with a suspicion of lateral ankle ligament injury underwent ultrasonography examination. Individuals who had at least six weeks of pain, with or without swelling, and point tenderness over the lateral portion of the ankle on physical examination were included. They chose 120 of these participants who had surgery to be a part of the study.

Arthroscopy was performed within one week (mean of four days) of ultrasonography. US was performed by a radiologist with seven years of experience and who was blinded to previous physical examination results and diagnoses.[18] Participants were positioned in supine with their foot maximally inverted and plantar flexed. They obtained both axial and transverse sonography of the ligaments. The ligaments were graded individually with a grading scale of grade 0, no injury; grade 1, stretched or swollen ligament without tear; grade 2, partial tear; and grade 3, complete tear of the ligament. Arthroscopy was performed by an experienced surgeon and the same grading system was used. [18] The results of the arthroscopy showed 18 sprains, 52 complete tears and 24 partial tears of the ATFL, 26 sprains, 27 partial tears and 12 complete tears of the CFL and 1 complete tear of the PTFL. The US findings were compared with the surgical findings and the sensitivity of US was found to be 98.9%, and the specificity was 96.2% for diagnosing an ATFL injury. The accuracy of US in diagnosing an ATFL injury was 84.2%. For diagnosing CFL injuries, the sensitivity of US was 93.8%, the specificity was 90.9% and accuracy was 83.3%. Researchers concluded that US is a cost effective and appropriate examination tool for detecting lateral ligament injuries, however, US is dependent on the expertise of the technician and therefore further research should determine criteria for examination and diagnosis.[18]

Gün et al sought to determine the ability of emergency physicians (EPs) to diagnose patients with a history of ankle inversion and suspected ATFL sprain with the use of bedside ultrasonography (BUS). The authors in the study used MR imaging as the reference standard.[19] (The EPs received three hours of didactic training and three hours of hands-on training by a radiologist in order to perform ultrasonography on the ankle joint and diagnose possible AFTL injury. Sixty-five patients (37% females), with a mean age of 34.03 $\pm$ 12.85, ranging from 18 to 72 years of age participated in the study. Participants with suspected inversion and chronic ankle injury were included in the study. Patients with fractures and open wounds around the ankle were excluded. During the BUS, the ligaments were determined to be ruptured if they were not depicted as hyperechoic bundles, indicated by a discontinuation of the bundles.[19] In comparison with MRI, researchers found BUS to have a sensitivity of 93.8%, CI: 79.2-99.2, a specificity of 100%, CI: 89.4-100, a positive predictive value of 100, CI: 88.4-100, and a -LR: 0.06. Researchers determined that the difference between the diagnostic accuracy of BUS and MR imaging was not statistically significant ($K = 0.938$, $p = 0.001$). This indicates that BUS can be a diagnostic tool to help with early and prompt diagnosis of ankles that have experienced acute trauma.[19]

Oae et al sought to evaluate the diagnostic value of radiographic examination, ultrasonography, and MR imaging in diagnosing ATFL injury in comparison with arthroscopy, the reference standard.[20] This prospective study included 34 patients in need of an operation to correct an osteochondral lesion, synovitis, or instability. There were 19 males and 15 females with a mean age of 29 years, ranging from 13 to 55 years. Nineteen patients had acute ankle injuries, while 15 participants had chronic injuries. Patients were excluded from the study if they were determined to be in the subacute phase or have a fracture. A separate blinded author, who had 10 years of experience in diagnosing musculoskeletal and orthopedic conditions, examined the images. This evaluator was blinded specifically to the participants' history and physical examination. The ankle arthroscopy was performed after the imaging examinations. For each diagnostic test, there were slight variations in the criteria for a positive diagnosis of a torn ATFL. [20] On stress radiograph, the amount of anterior displacement from the talus to the posterior lip of the tibia was measured. A difference of three mm. or greater was considered to be a positive test, indicating lateral instability. The diagnostic criteria for ligament injury on US were discontinuity and hypoechoic lesion of the AFTL. On MR imaging, discontinuity, a wavy or curved contour, and increased signal intensity within the ligament indicated ligament injury. The reference standard classified a ligament injury by an abnormal course of the ligament, a decrease in the tautness of the ligament, and an avulsion at the attachment of the fibula or talus. [20] Using ankle arthroscopy, 30 of the 34 patients were positive for an ATFL injury. Compared to the reference standard, the stress radiography had a 71% accuracy rate, US had a 91% accuracy rate, and MR imaging had a 97% accuracy. [20] After com-

paring these diagnostic tests to the reference standard, the authors believe that US and MR imaging has satisfactory results when reporting ATFL injury. Based on the data, MR imaging has a higher specificity than US in locating the area of ligament injury. The authors comment that one of the limitations of the study is that arthroscopy is unable to detect intraligamentous partial tears, but when using US, examiners can detect intraligamentous tears. This may have influenced whether or not a ligament was considered torn and reflected as differences in the results between US and arthroscopy.[20]

Guillodo et al[21] evaluated the value of ultrasonography in diagnosing ATFL injury in patients with CAI in comparison to computed arthrotomography (CTA). [21] The ages of participants ranged from 15 to 69 years (mean, 30.1 ± 10.6 years). Inclusion criteria of this study were athletes with ankle injury symptoms (persistent pain and/or instability) present for approximately three months and athletes who were prohibited from participation in sports. [21] Anterior drawer stress test and US were performed by the same sports medicine specialist who had 20 years of experience working with sports medicine and US. The CTA was conducted in the same radiological center using a standardized protocol. Thirty-two out of the 56 patients had a positive anterior drawer test, 34 out of 56 patients had evidence of clinical laxity on US, while CTA found evidence of ATFL injury in 39 out of 55 patients. The reference standard gathered inconclusive results with one patient. [21] When comparing CTA to US, the kappa value reported was k = 0.76. The sensitivity, specificity, positive predictive value, and negative predictive value for US compared to CTA were 84.6% (33/39), 100% (16/16), 100% (33/33), and 72.7% (16/22), respectively. This study concluded that US can be used after a radiographic assessment for athletes with chronic ankle instability.[21]

DISCUSSION

The purpose of this systematic review was to investigate the effectiveness of ultrasonography (US) in diagnosing CAI, in comparison with other diagnostic tools. The results indicate that US is a valuable diagnostic tool for chronic ankle instability in all six of the studies that were analyzed, demonstrating high sensitivity and specificity when compared to various reference standards. The summary table reveals that all six articles included in this systematic review came to the same conclusion: US is an effective diagnostic tool in detecting chronic ankle instability (CAI). The table shows statistical data that reveals high inter observer agreement, high sensitivity, high specificity, and high positive likelihood ratios, which together indicate that US is an effective diagnostic tool.

The reference standards used to measure the effectiveness of US included arthroscopy in three studies, MRI in two studies, stress X-Ray in one study, anterior drawer stress test in one study, and CTA in one study. These tools have all been used to diagnose CAI, and are therefore appropriate reference standards for determining the reliability and accuracy of US. The sample sizes ranged from 34 to 120 participants, with all of the studies having more males than females. All of the studies had samples that were considered to be representative of the target population. US examinations in the studies were performed in some degree of inversion and plantarflexion, using moderate to maximal stresses. One study also obtained images with the ankle in the resting position, and one study did not disclose specifics of test positioning. Damage to the anterior talofibular ligament (ATFL) was identified by various criteria in the studies, including interruption of the ligament, laxity of the ligament, hypoechoic lesions in the ligament, ligament thickening, and absorption of the ligament.

In comparison with arthroscopy, the highest quality reference standard, US had a sensitivity of 98.9% and 97.7% and specificity of 96.2% and 92.3%.[15,18] Oae et al also found US to have an 87% accuracy rate (sensitivity), when measured against arthroscopy. In comparison with MRI, US had a sensitivity of 93.8% and specificity of 100%.[19] The research performed by Cheng et al was the only study included in the systematic review that looked at all three ligaments of the lateral ankle and not just the ATFL. Their results still demonstrated high specificity and sensitivity results for the use of US in diagnosing ATFL injury.

Question three on the QUADAS table inquires about the time period between the performance of

diagnostic US and the reference standard. In five out of the six articles, the researchers did not clearly state the time that transpired between diagnostic imaging tests, resulting in the classification of unclear. If the tests were performed with a greater amount of time between them, it is possible that the condition of the ligaments could have worsened or changed to some degree, which would decrease the internal validity of the study. In addition, five out of the six articles were unclear with regard to question 14 that related to determining whether treatment was withheld until both diagnostic imaging tests were performed,. This piece of information is critical because treatment can influence the structural representation of the ligaments.

ULTRASOUND VALUE WITH CHRONIC ANKLE INSTABILITY

The outcome measures used to assess the integrity of the ATFL on US included a four point grading scale, the presence of hypoechoic lesions, disruption of ligamentous continuity, or laxity. Examiners' interpretations of US images, using these grading systems, resulted in high sensitivity, specificity, and accuracy for US when compared to the reference standards throughout all six articles. All possible tools used to clinically diagnose CAI were compared with US and US was deemed effective in correctly diagnosing ankle instability.

In concordance, Tourne et al[22] stated that the primary use of diagnostic US at the ankle is in the dynamic e valuation of the lateral collateral ligaments. The authors also state that it can be helpful in the identification of anterolateral impingement, but that it is not useful in assessing bone or cartilage. Unlike other diagnostic tools, US allows for a real-time visualization of the ATFL. This is important because this allows an examiner to differentiate between the grades of instability, and to accurately localize the injury. US is a valuable tool in the diagnosis of CAI because it is cost effective, it does not expose the patient to radiation, and it is efficient, and noninvasive [23]. Although US is known to be operator dependent, according to the study performed by Gun et al [19], emergency physicians were taught how to use and diagnose CAI of the ATFL with US in six hours of training by a radiologist. The inter observer agreement was high and the emergency physicians were able to accurately diagnosis CAI of the ATFL. This implies that although US is operator dependent, it does not take an extensive amount of time to learn and master the diagnostic skills.[19]

ACCURACY IN DIAGNOSING DEGREES OF INSTABILITY

US not only detects injury to the ATFL, but it can also classify the degrees of instability. According to the study performed by Hua et al.[15]AFTL injury was classified by US as " (i) ligament tear: a partial or total interruption of the ligament fibers at the fibular side, talar side or in the mid stance; (ii) lax ligament : the ligament remained curved when the ankle was in the maximum inversion and plantar flexion; (iii) thick ligament : the width of the ligament was > 24 mm or > 20% of the contralateral normal ligament; (iv) pigment absorbed: no ligament fibers were seen; and (iv) non- union of avulsion fracture of the lateral malleolus".[15] The ability of US to classify the grade of injury indicates the severity of damage to the ankle, allowing for a more specific diagnosis. With more accurate diagnosis, therapists can create more appropriate goals, treatment plans, and may be better able to predict the prognosis for a patient.

Many of the studies included in this systematic review utilized an anterior draw stress test as one of the comparative diagnostic tools. The anterior draw test is a diagnostic tool that entry-level physical therapists are taught to perform, and it is successful in diagnosing injuries to the ATFL. In the study conducted by Guillodo et al,[21] the anterior draw stress test had a kappa value of 0.62 and US had a kappa value of 0.76, when compared to computed athrotomography (CTA).[21] These values demonstrate that US has a higher inter observer agreement than the anterior drawer stress test. Also, US was accurate in successfully differentiating different grades of ATFL injuries according to Cheng et al.[18] The anterior drawer stress test can be used to determine an injury to an ankle with accuracy but it is not as capable at determining the severity of tissue injury. In a clinical setting, it is pertinent for the therapist to have the ability to determine not only the presence but also the severity of the injury in order to decide when a patient is a candidate for physical therapy

interventions or a referral for possible surgery. US offers this acuity when evaluating the grade of injury to a patient's ligaments and can provide excellent information for the clinician related to decision making when determining the best possible plan of care for the patient.

One study, performed by Margetic & Pavic [24] found a discrepancy between US and MRI in the ability to decipher the grade of the ligamentous injury. US was able to diagnose considerably more ligament sprain injuries than MRI, while MRI was able to diagnose significantly more complete ligament ruptures than US. The authors concluded that MRI should always be consulted to confirm the need for surgical treatment.[24] Talijanovic et al[25] described the anatomy of the lateral aspect of the ankle, focusing on the peroneal tendon, and current imaging tools to identify normal anatomy and detect injuries.[25] The researchers concluded that dynamic US is the best imaging technique for the evaluation of peroneal tendon subluxation and/or dislocation.

VALUE OF US TO PT

The knowledge of US and its diagnostic capability is extremely beneficial to the profession of physical therapy. As mentioned, physical therapists can use the results from US images to create treatment plans, goals, and to assist with predicting the patients' prognosis and outcomes. Physical therapists could implement specific treatment protocols because they will have definitive information to choose appropriate interventions specific to the type and extent of injury experienced by the patient.[8] By identifying the grade of injury, physical therapists can choose interventions tailored specifically to the patient's injury and phase of healing, leading to more efficient and effective treatment.

The use of US is part of the future of the Physical Therapy practice. It will increase the quality of care and allow for a decreased number of outpatient visits because the diagnosis will accurately reveal the injury severity and location. Also, the efficiency of US allows for early diagnosis of CAI, which minimizes the risk of mechanical and functional instability over time. Early detection can also help delay or accelerate the need for invasive surgery based upon the severity of the injury.[8]

TRAINING

In the study by Gun et al[19] bedside US examiners had six hours of training before they examined the participants included in the emergency department. [19] With such limited amount of training, these examiners were able to accurately identify 30 true positives, and 33 true negatives. There were zero false positives, and two false negatives. [19] This is a promising finding, as it appears that with minimal training examiners can accurately assess suspected ATFL injuries using US. Therapists are encouraged to investigate the use and the benefits of using US in PT clinics. Cost effectiveness as well as time needed to ensure adequate learning regarding the use of US machines by therapists should be investigated.

CONCLUSION

The results of the this systematic review indicate that US is a highly sensitive, specific, and accurate imaging technique that can be used to diagnose lateral ankle injury and CAI. The addition of US as part of physical therapy examination will allow for an accurate initial evaluation, excellent treatment, and improved discharge planning. Such outcomes represent a better quality care for patients and an evidence based shift of the profession towards improved patient diagnosis and management.

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